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FOREIGN TECHNOLOGY DIVISION



APPLICATION OF GLASS LUBRICANT DURING EXTRUSION OF TITANIUM ALLOYS

by

I. V. Anisimova, G. B. Kozlov, et al.



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EXTRUSION OF TITANIUM ALLOYS

By: I. V. Anisimova, G. B. Kozlov, et al.

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WP-APB, OHIO.

U. S. BOARD ON GEOGRAPHIC NAMES transliteration SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	<i>А а</i>	A, a	Р р	<i>Р р</i>	R, r
Б б	<i>Б б</i>	B, b	С с	<i>С с</i>	S, s
В в	<i>В в</i>	V, v	Т т	<i>Т т</i>	T, t
Г г	<i>Г г</i>	G, g	У у	<i>У у</i>	U, u
Д д	<i>Д д</i>	D, d	Ф ф	<i>Ф ф</i>	F, f
Е е	<i>Е е</i>	Ye, ye; E, e*	Х х	<i>Х х</i>	Kh, kh
Ж ж	<i>Ж ж</i>	Zh, zh	Ц ц	<i>Ц ц</i>	Ts, ts
З з	<i>З з</i>	Z, z	Ч ч	<i>Ч ч</i>	Ch, ch
И и	<i>И и</i>	I, i	Ш ш	<i>Ш ш</i>	Sh, sh
Й й	<i>Й й</i>	Y, y	Щ щ	<i>Щ щ</i>	Shch, shch
К к	<i>К к</i>	K, k	Ъ ъ	<i>Ъ ъ</i>	"
Л л	<i>Л л</i>	L, l	Ы ы	<i>Ы ы</i>	Y, y
М м	<i>М м</i>	M, m	Ь ь	<i>Ь ь</i>	'
Н н	<i>Н н</i>	N, n	Э э	<i>Э э</i>	E, e
О о	<i>О о</i>	O, o	Ю ю	<i>Ю ю</i>	Yu, yu
П п	<i>П п</i>	P, p	Я я	<i>Я я</i>	Ya, ya

- * ye initially, after vowels, and after ъ, Ъ; e elsewhere.
When written as ѣ in Russian, transliterate as yѣ or ѣ.
The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

FOLLOWING ARE THE CORRESPONDING RUSSIAN AND ENGLISH
DESIGNATIONS OF THE TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	sin ⁻¹
arc cos	cos ⁻¹
arc tg	tan ⁻¹
arc ctg	cot ⁻¹
arc sec	sec ⁻¹
arc cosec	csc ⁻¹
arc sh	sinh ⁻¹
arc ch	cosh ⁻¹
arc th	tanh ⁻¹
arc cth	coth ⁻¹
arc sch	sech ⁻¹
arc csch	csch ⁻¹
<hr/>	
rot	curl
lg	log

APPLICATION OF GLASS LUBRICANT DURING EXTRUSION OF TITANIUM ALLOYS

I. V. Anisimova, G. B. Kozlov, Ye. M. Nepomnyashchiy
A. G. Sergeyev, L. G. Stepan'skiy
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Titanium is distinguished by a raised tendency to adhere to the contact surfaces of a tool, which leads to accelerated tool wear. Low thermal conductivity of titanium alloys (4-8 times less than for alloy steels) causes a large temperature drop near the surface layers of the billet, leading to the appearance of considerable strength heterogeneity of material, which is reflected on irregularity of deformation and the surface quality of extruded articles. Fast oxidizability and intense gas saturability of titanium at high temperatures causes a substantial change of mechanical properties of surface layers of the billet, which also impairs the surface quality of the article and accelerates die wear. All of this considerably complicate the selection of process lubricants.

At present the most suitable lubricants for hot extrusion of steel, titanium and certain other alloys are considered glass lubricants [1]. However, information about their effective application during extrusion of titanium is extremely limited [2].

The purpose of the work, conducted by All-Union Scientific Research, Planning and Design Institute of Metallurgical Machinery (VNIIMETMASH) jointly with the State Institute of Glass and Stupinsk Metallurgical Combine, was to determine the rational

compositions of glass lubricants and methods of their application on the billet and tool during hot extrusion of four characteristic titanium alloys [3]: VT1-1, OT4-0, VT3-1 and VT5-1.

Extrusion was performed on a horizontal hydraulic press with a force of 1000 t with a pump-battery drive. Speed of travel of the mobile cross arm was 50-60 mm/s. The press had a die subassembly of bit construction and a press-punch withdrawable from the axis of extrusion during feed of the billet into the container. The billets were heated in a continuous induction furnace of industrial frequency with horizontal arrangement of the muffle. During extrusion of bars with diameter 15, 20, 25 and 30 mm, and also T-shape, corner and channel bar type profiles, there was used a container 115 mm in diameter. Dies had approach taper angle 135° . Before extrusion the forged titanium billets were subjected to complete lathe work; during this one end of the billet was given a shape corresponding to the front die face. Twelve brands of glass were tested: No. 176, No. 209, No. 176a, No. 185v, No. 10S, No. 271, No. 295apv, No. 269, No. 295, No. 291a41, No. 295a16, and No. 295a. The numbers of all the glass correspond to the numbering system of the State Institute of Glass.

The first part of the investigations was aimed at selection of glass suspension coatings of billets before heating for protecting their surface from oxidation and gas saturation and creation of a layer facilitating the application of additional glass lubricant. The composition of suspension included: 85-90% glass powder with grain size 0.07 mm, 10-15% water glass and water, added to suspension density 1.8-2 g/cm³. Before application of glass suspension the billets were degreased. Thickness of the coating layer was 0.5-0.8 mm. The billets were dried in air.

As shown by experiments, with viscosity of glass over 6000-6500 poises, complete fusion of the coating did not occur during heating of the billet; this prevented the supply of lubricant to the die hole. On the other hand, low viscosity of glass (less than 700-800 poises) caused disturbance of the continuity of lubricating film,

its slipping from the heated billet during the necessary duration of heating (40-60 min). For VT1-1 and OT4-0 alloys at heating temperatures before extrusion 800-900°C the best results were obtained on glass suspension coating from glass No. 295, and for alloys VT3-1 and VT5-1 at heating temperatures 950-1150°C - from glass No. 185v, and also from glass No. 176 and No. 176a.

Use of only one glass suspension coating as lubricant permitted extruding rods from VT3-1 alloy with high surface quality at elongation coefficients up to 20 (Fig. 1). However, with this the specific forces of extrusion are essentially increased (up to 100 kg/mm² when heating to 1150°C). Furthermore, there was observed instability of work of the lubricating coating, in certain cases leading to its disturbance and the formation of deep longitudinal scratches on the surface of extruded bars, apparently caused by the gradual adherence of titanium to the tool.

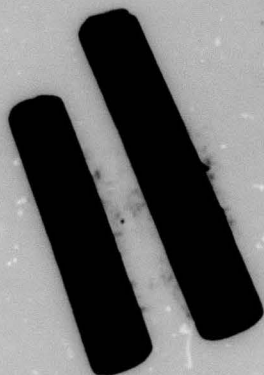


Fig. 1. Rods, pressed with the use of glass suspension coating.

The second part of the investigation was dedicated to selection of additional glass for glass suspension coating, applied before heating, for lubrication of the lateral surface of the heated billet (by means of rounding up) and the die (with the aid of die washers). Application of such a method of lubrication permitted not only considerably lowering the specific force of extrusion (Table 1), but also assurance of stable feed of lubricant into the die hole, at least at elongation coefficients up to 60. However, in contrast to the use of one glass suspension coating in this case

Table 1.

Alloy	Article (dimensions in mm)	Elongation coefficient	Extrusion temperature, in °C	Average specific force in kg/mm ²
VT1-1	Rods Ø 20	33.3	830-850	40
VT3-1	Rods Ø 20	33.3	950-1000	65
VT5-1	Rods Ø 20	33.3	900-920	80
OT4-0	Corner 35 × 6	27.7	885-910	50

on the surface of titanium extruded articles under the layer of glass there are observed characteristic defects in the form of transverse ripples and longitudinal folds (Fig. 2). It is necessary to note that the use of rounding up the heated billets by glass powder and the die washers without glass suspension coating leads to considerably deeper defects, primarily in the form of longitudinal folds. It is noticed that low viscosity of glass for washers (less than 100 poises) leads to increase of the depth of ripples; on the other hand, glass whose viscosity is higher than that of the coating, for all practical purposes do not work as lubricant. Depth and frequency of location of defects on the surface of extruded articles can be considerably decreased at a certain combination of glass of suspension coating, glass utilized during rounding up, and glass for washers.

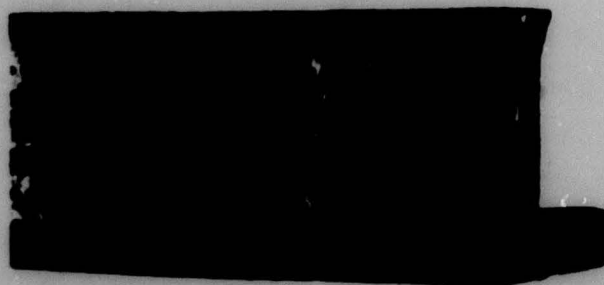


Fig. 2. Profile, extruded with the application of glass lubricant in the form of a suspension coating, rounding up and washers (characteristic surface defects).

The most successful combinations of glass for combined use during extrusion of articles from VT1-1, OT4-0 and VT3-1 alloys, established as a result of investigation, are listed in Figs. 3 and 4. On Figs. 3 and 4 there are graphs of the change of viscosity of glass of optimum compositions (Table 2) depending upon the temperature. Dashed lines mark the temperature ranges of heating of billets before extrusion.

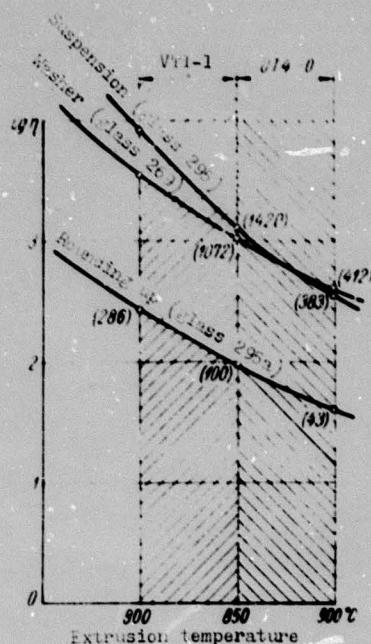


Fig. 3.

Fig. 3. Viscosity of glass of optimum composition for VT1-1 and OT4-0 alloys.

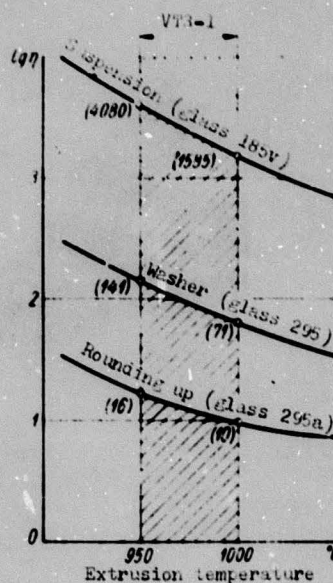


Fig. 4.

Fig. 4. Viscosity of glass of optimum composition for VT3-1 alloy.

Table 2.

No. of glass	Chemical composition in %								
	SiO ₂	CaO	MgO	Na ₂ O	K ₂ O	Al ₂ O ₃	B ₂ O ₃	PbO	FeO
185v	60	5	—	12	—	3	20	—	—
269	40	5	—	—	25	—	10	—	20
295	33,5	6	4,5	16,5	—	—	39,5	—	—
295a	33,5	12	4	21,5	—	—	18	10	—

Combined use of glass lubricant turned out to be sufficiently effective during extrusion of thin-walled T-shape profile with dimensions 30×1.5 mm made from alloy OT4-0. Extrusion was performed on a vertical press with force 200 t at speed of travel of mobile cross arm around 250 mm/s; elongation coefficient was 14.5. Longitudinal folds were not observed with this, and shallow transverse ripples remained only at the peak of the webs (Fig. 5).



Fig. 5. Thin-walled T-shape, extruded with the application of glass lubricant in the form of suspension coating, rounding up and washers.

For alloy VT5-1 not one of the tested compositions could be recognized as optimum because of the large number of defects on the surface of the article, although the latter remains completely covered by a layer of glass. More acceptable were glass No. 185v - for suspension coating, No. 295a - for rounding up and No. 295apv - for die washers.

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ABSTRACT

An investigation was made of

(U) VNIIMETMASH in conjunction with the State Institute for Glass and the Stupinskiy Metallurgical Combine investigated the lubricating properties of several glasses in extruding VT1-1 titanium and OT4-0, VT3-1 and VT5-1 titanium alloys. Degreased alloy specimens were dipped in a suspension of glass powder (0.07 mm particle size) mixed with water and water glass with a density of 1.8-2 g/cm (super-script 3) and dried in air. The coatings obtained were 0.5-0.8 mm thick. Best results in extrusion of VT1-1 and OT4-0 were obtained with No. 295 glass and in extrusion of VT3-1 and VT5-1 with No. 185v glass.